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(54) Height control for vehicle air suspension

(57) A trailer (100) or other wheeled vehicle with an air suspension (12 - 17) is provided with a wheel rotation sensor (5) which generates a control signal causing the air suspension to be reset to an in-transport (raised) condition from a loading/unloading (lowered) condition in which the load might be damaged by movement of the trailer. An electronic control circuit (not shown) is provided with a power saving circuit which prevents repeated re-setting of the air suspension to the in-transport condition.

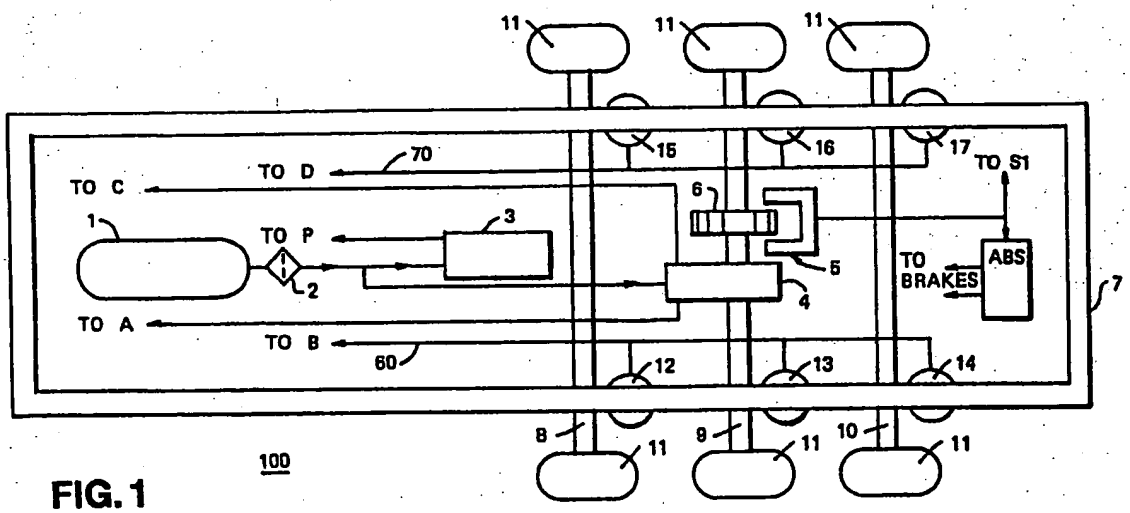

FIG. 1

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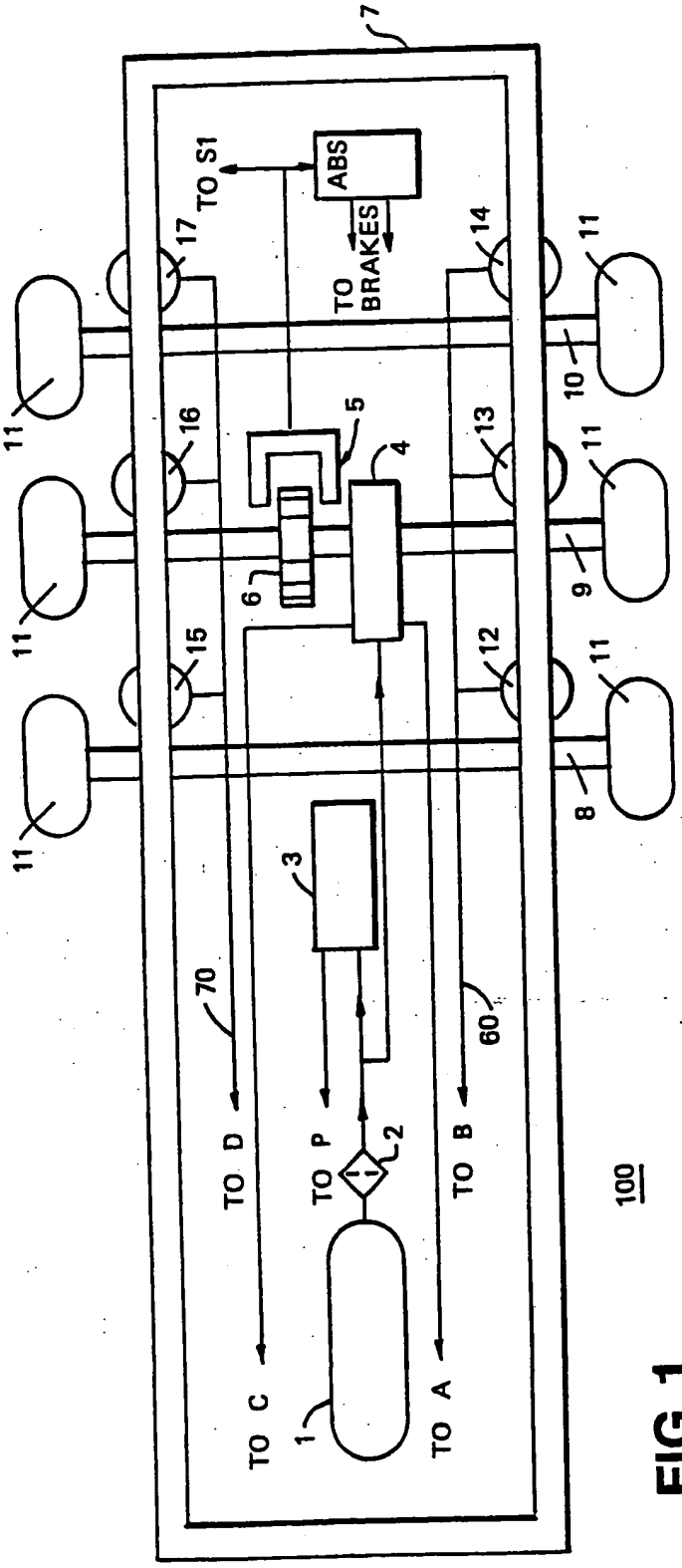
7
ABS
TO S1
TO BRAKES
17
14
11
10
16
5
4
13
6
9
15
12
8
3
70
60
TO D
TO P
TO B
TO C
TO A
2
1
100

FIG. 1

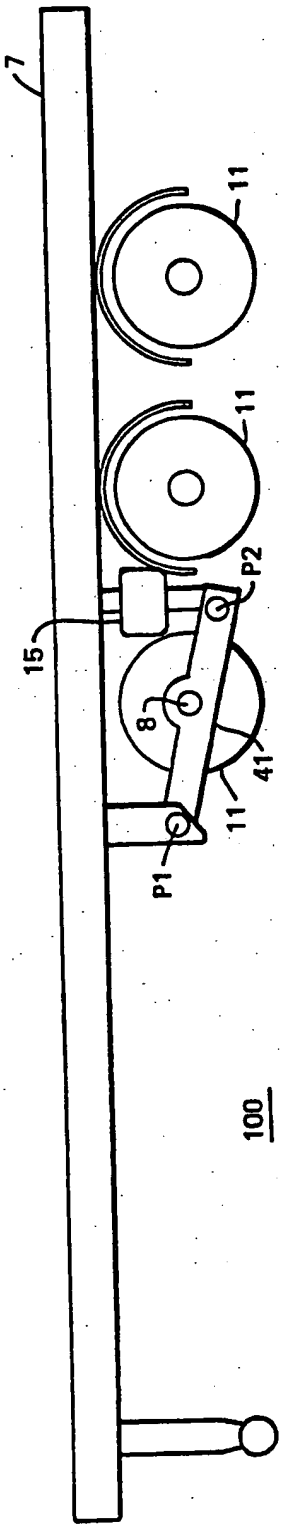
7
11
11
P2
15
8
41
11
P1
100

FIG. 2

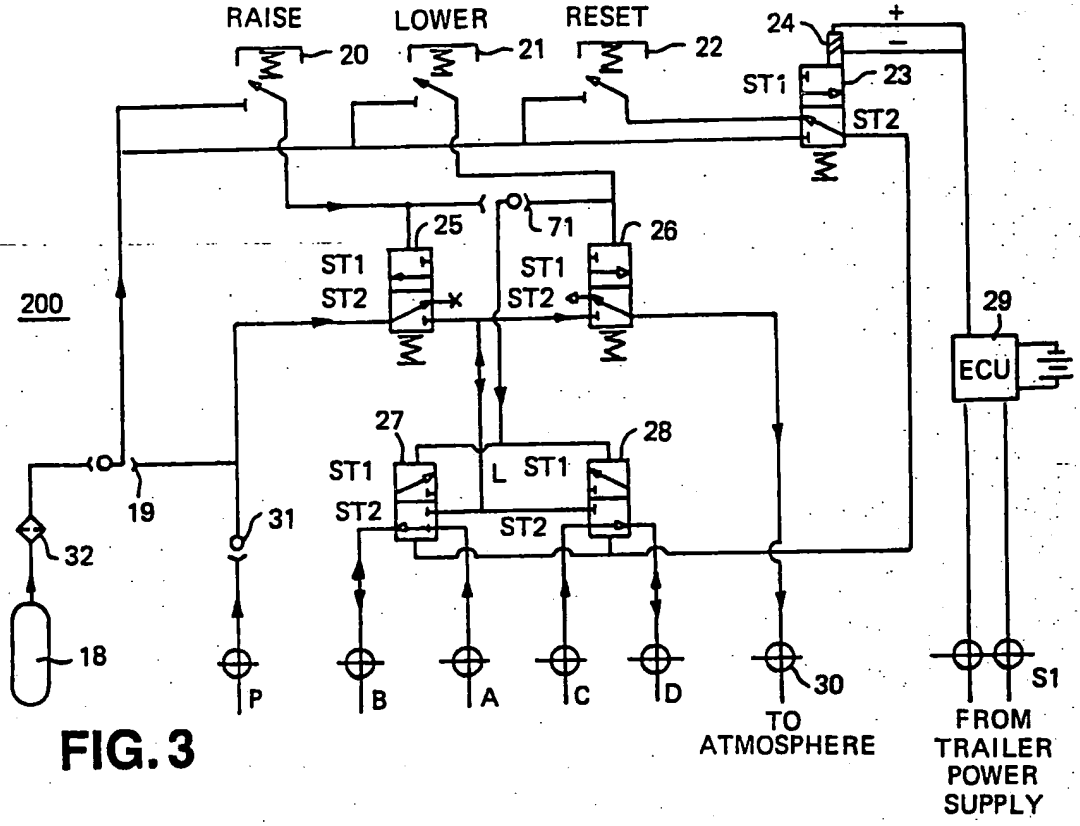
RAISE
LOWER
RESET
20
21
22
24
+
−
ST1
23
ST2
25
71
26
ST1
ST2
ST1
ST2
200
29
ECU
27
28
ST1
L ST1
ST2
ST2
19
31
32
18
P
B
A
C
D
30
TO ATMOSPHERE
S1
FROM TRAILER POWER SUPPLY

FIG. 3

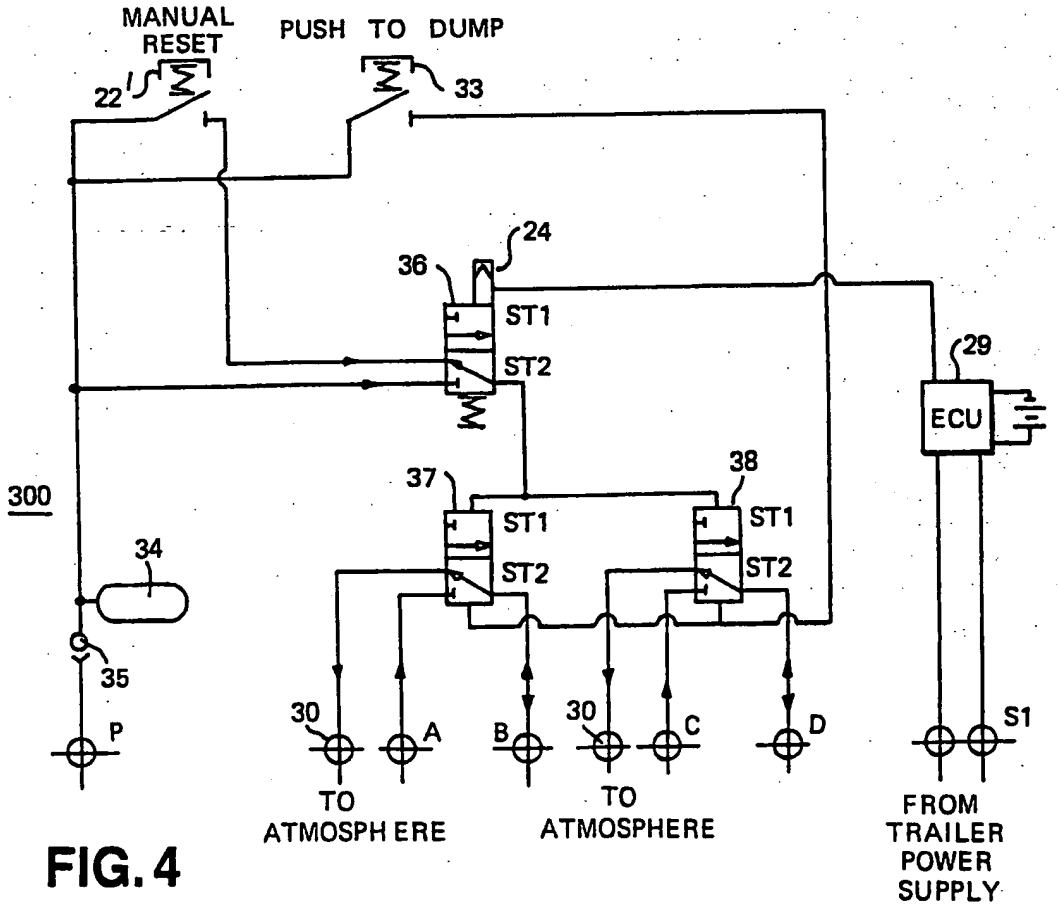
MANUAL RESET
PUSH TO DUMP
22
33
24
36
ST1
ST2
29
ECU
37
38
ST1
ST1
ST2
ST2
300
34
35
P
30
A
B
30
C
D
S1
TO ATMOSPHERE
TO ATMOSPHERE
FROM TRAILER POWER SUPPLY

FIG. 4

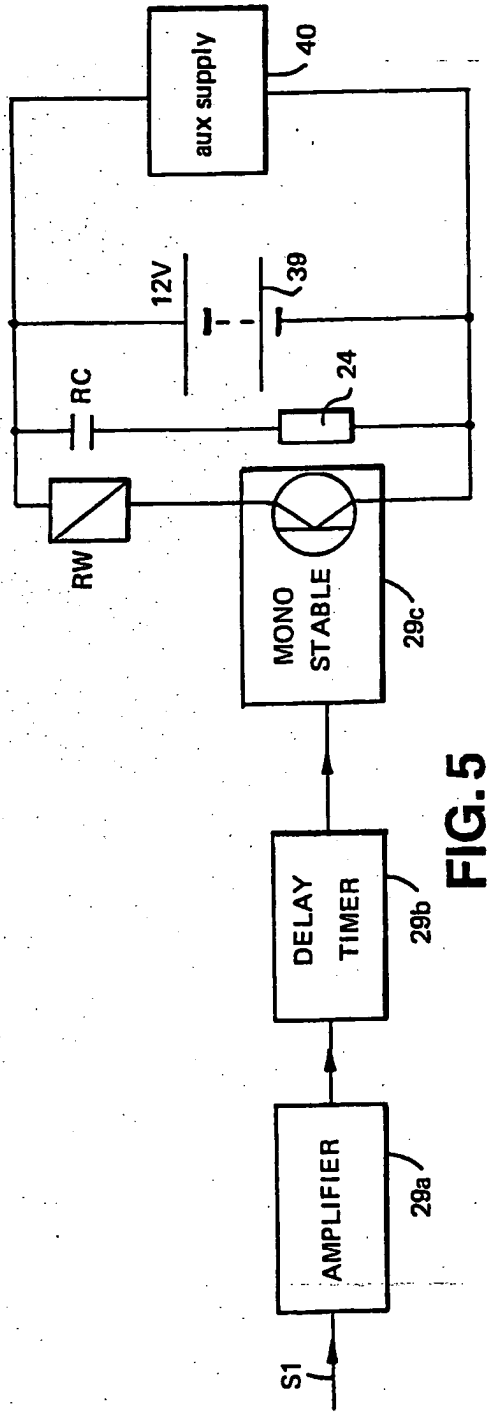
aux supply
40
12V
39
RC
24
RW
MONO STABLE
29c
DELAY TIMER
29b
AMPLIFIER
29a
S1

FIG.5

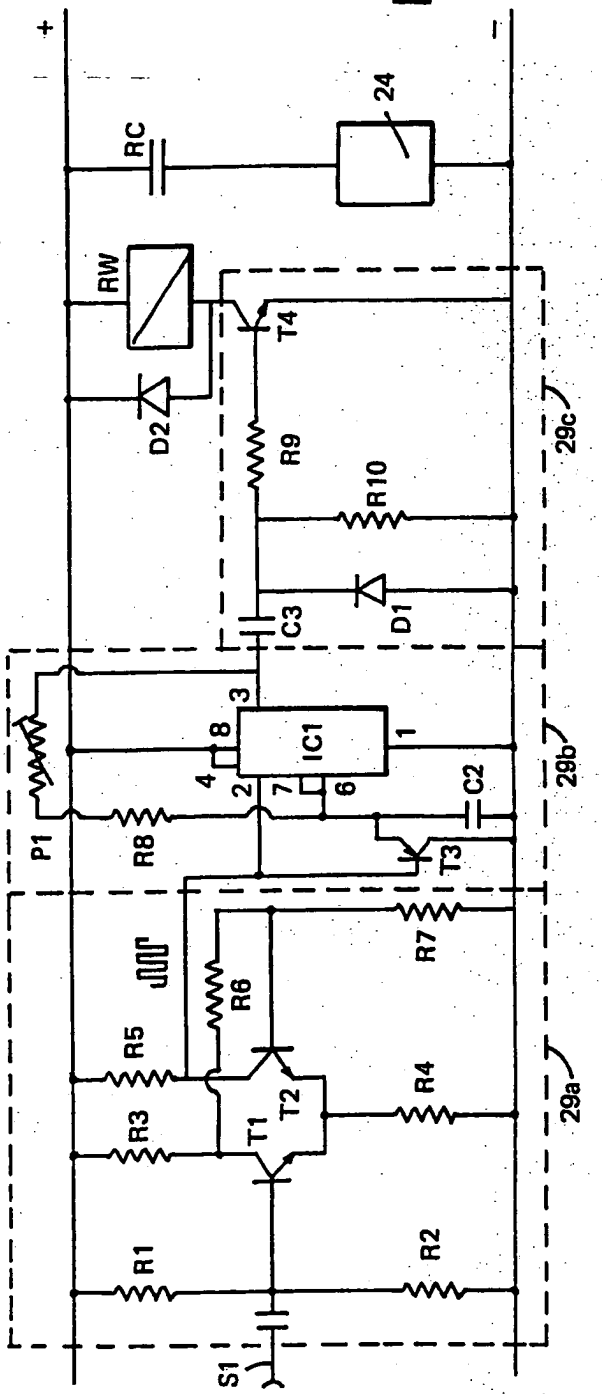
+
-
RC
24
RW
T4
D2
R9
R10
29c
C3
D1
IC1
P1
R8
C2
T3
29b
R7
R6
R5
R4
T2
T1
R3
29a
R1
R2
S1

FIG.6

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VEHICLE WITH AIR SUSPENSION SYSTEM

The invention relates to vehicles with air suspension systems and in particular to air suspension systems for load carrying vehicles. Such vehicles are usually trailer units and comprise a chassis having road wheels above which is a cargo compartment including a load carrying platform. Air springs are present to raise the compartment to an in-transport condition and to lower the compartment to the level of a loading bay or dock, e.g. for roll off and roll on. When such a vehicle enters a loading bay or dock the vehicle platform height will usually be different from that of the bay or dock. The air suspension system includes control means for the driver to use the air springs to raise or lower the height of the platform relative to the height of the bay or dock.

It is apparent that it is necessary for the height of the vehicle platform to be returned to the normal ride height before the vehicle leaves the bay or dock. Unfortunately the driver can forget to make the adjustment and damage is caused to the suspension system and other components of the trailer if the vehicle is driven with the platform in the wrong position. It is, therefore, known to automatically restore the height of the vehicle platform, for example when pressurising the air brake system in order to drive off, see e.g. US-A-4558886 published in 1985. It is an object of this invention to provide an improved control system.

The invention provides a wheeled vehicle in accordance with Claim 1.

Preferably the control means is responsive to the electric signal to raise the platform from a loading or unloading position to an in-transport condition by pumping air into the air spring.

Movement of the wheels may be sensed in either direction of rotation e.g. by a rotation sensor coupled to an axle carrying road wheels of the vehicle. It is a much preferred feature of the invention that the sensor present for the anti lock braking system is also used to generate a signal for the purpose of the invention.

Most preferably the system of the invention includes an electrically operated pneumatic valve which is energised on receipt of a signal from the sensor to activate control means to adjust the height of the platform. The electric power to drive the valve may be drawn from the vehicle's supply. It is a further preferred feature of the invention however that the signal be supplied to a switch in a battery powered circuit used to operate the pneumatic valve. In a further feature of the invention a switch circuit is present to reduce draining of power from the battery. Other preferred features are defined in the dependent claims.

In order that the invention may be well understood the preferred embodiments will now be described with reference to the accompanying schematic drawings, in which:

Figure 1 is a schematic plan view of a trailer in accordance with the invention;

Figure 2 is a side elevation of the trailer of Figure 1, with one road wheel removed to show an air spring suspension unit;

Figure 3 is a pneumatic circuit diagram of one pneumatic control system for use with the trailer of Figure 1;

Figure 4 is a pneumatic circuit diagram of another pneumatic control system for use with the trailer of Figure 1;

Figure 5 is a block schematic diagram of the electronic control unit 29 of Figures 3 and 4, and

Figure 6 is a more detailed circuit diagram of the electronic control unit 29.

Referring to Figures 1 and 2, a trailer 100 comprises a load-carrying platform 7 (which is depicted as a rectangular frame for the sake of simplicity) supported at the rear on two sets of three air springs 12, 13, 14 and 15, 16, 17 respectively. As shown in Figure 2, air spring 15 acts between the platform 7 and a pivot P2 at one end of a beam 41 which is connected by a pivot P1 at its opposite end to a downward extension of the platform. Beam 41 is supported at its mid-portion on axle 8 carrying road wheels 11, and the beams (not shown) of the other air springs are similarly supported on axles 9 and 10 carrying further road wheels 11. It will be apparent that the height of platform 7 above ground level will depend upon the extension of air springs 12 to 17. These air springs may be "Airide" ® air springs as made by Firestone Industrial Products Co., Noblesville, USA. Air springs 12 to 14 are supplied with pressurised air via a common air line 60 (Figure 1) and air springs 15 to 17 are similarly supplied with pressurised air via a common air line 70 (Figure 1).

Air lines 60 and 70 interface with air lines B and D respectively of the pneumatic control arrangements shown in Figures 3 and 4, as described below in detail.

However, at this stage it should be noted that the required air pressure is ultimately derived from a reservoir 1 which is connected via an air filter 2 to a height limiting valve 3 and a height control valve 4. These valves are both coupled (by means not shown) between the axle assembly and platform 7 of the trailer 100, valve 3 serving to limit the height to which the platform can be raised and valve 4 having two output air lines (coupled to lines C and A respectively of the arrangement of Figure 3 or Figure 4) which cut off air when the height of either the left or right side of platform 7 exceeds a predetermined threshold. The output of valve 3 is connected to line P of Figure 3 or Figure 4). Height limiting and height control valves are commonly used in air suspension systems and accordingly it is not necessary to describe them in further detail.

The trailer 100 shown in Figure 1 also includes an antilock braking system ABS which includes a permanent magnet variable reluctance rotation sensor 5 which senses the rotational speed of a toothed wheel 6 mounted on axle 9. The antilock braking system is of a standard type and includes the normal outputs to the trailer brakes (not shown).

As shown in Figures 1, 3 and 4, the electric signal output from speed sensor 5 is fed to input S1 of an electronic control unit 29 which controls the pneumatic valve arrangements of Figures 3 and 4. These will now be described.

The control arrangement 200 shown in Figure 3 comprises a spring-biased pneumatic valve 23 operated by a solenoid 24 and two further spring biased pneumatic valves 25 and 26, each operated by pilot lines. The arrangement further comprises two memory (i.e. latching) pneumatic valves 27 and 28 which are associated with sets of air springs 12 to 14 and 15 to 17 respectively (see Figure 1). Each of the above valves is a 3-port, 2-state valve, two states ST1 and ST2 being

depicted adjacent one another and pilot lines being shown entering the short sides of the rectangle constituted by the two possible states ST1 and ST2, as is conventional.

Manually operable RAISE, LOWER and RESET valves 20, 21 and 22 have their input ports commonly connected to the output of a shuttle valve 19, whose input ports are respectively connected via an air filter 32 to a pressurised air reservoir 18, and via a non-return valve 31 to line P from height limiting valve 3 (figure 1).

The output ports of RAISE and LOWER valves 20 and 21 are connected to the respective input ports of a shuttle valve 71, whose output port is connected (in common to those pilot lines of memory valves 27 and 28 which are associated with state ST1. The output ports of valves 20 and 21 are also connected to the pilot lines of spring -biased valves 25 and 26.

The arrangement of Figure 3 operates as follows. When the trailer is stationary the platform 7 can be raised, lowered and reset manually by valves 20, 21 and 22 respectively. For example, depression of the push button to operate RAISE valve 20 applies pressure to the pilot line of valve 25, which accordingly enters state ST1, and applies pressure via shuttle valve 71 to the pilot lines of memory valves 27 and 28, which accordingly latch to state ST1. Consequently pressurised air from valve 19 and/or 31 enters valve 25 (in state ST1) and is conveyed via valves 27 and 28 (also in state ST1) to lines B and D respectively, and hence to lines 60 and 70 (Figure 1) to inflate the sets of air springs 12 to 14 and 15 to 17 and raise the platform 7.

Depression of the pushbutton of LOWER valve 21 sets valve 26 to state ST1 via its pilot line and also sets memory valves 27 and 28 to state ST1 (via shuttle valve 71

and their respective pilot lines). Consequently air from the air springs flows through lines B and D to a line L connecting their output ports, and thence via valve 26 (in state ST1) and an outlet 30 to atmosphere.

Operation of RESET valve 22 applies pressure via the lower pilot line of valves 27 and 28, but only if valve 23 is in state ST2. Assuming valve 23 is in this state, memory valves 27 and 28 are latched back to state ST2 in which line B is connected to line A and line C is connected to line D i.e. the two sets of air springs 12 to 14 and 15 to 17 are connected to the respective outputs from height control valve 4 (Figure 1). This is the "in-transport" condition in which the height of platform 7 (and also its inclination) is maintained during transport.

When valve 23 is set in state ST1 (under the action of a solenoid 24) pressure is applied via the lower pilot line of memory valves 27 and 28 and they remain latched in state ST2 (I.e in the "in-transport" condition) irrespective of the operation of valves 20 to 22. Accordingly, even by momentarily putting valve 23 in state ST1, the valves 27 and 28 are re-set to the in-transport condition in which it is safe for the trailer suspension to experience shocks from the road without damaging the load.

The conditions under which valve 23 is set to state ST1 are described in detail below, with reference to Figures 5 and 6. However, before doing so, the pneumatic arrangement 300 of Figure 4 will be referred to.

This arrangement is simpler than that of Figure 3, and comprises a manually operable RESET valve 22^1 (similar to RESET valve 22 of Fig. 3) and manually operable DUMP valve 33, both supplied with pressurised air from a reservoir 34 and from air line P via a non-return valve 35. The arrangement includes a two state 3-port spring biased valve 36 operated by a solenoid 24, which in state ST1

automatically resets 2-state 3-port memory valves 37 and 38 to the "in-transport" state ST1. DUMP valve 33 sets these memory valves to state ST2 which enables the air springs to exhaust to atmosphere via outlet 30, thus lowering platform 7 to a height suitable for loading or unloading. In this lowered condition, there is a danger that any shocks from the road experienced by the suspension during transport will damage the load.

In accordance with the invention, this danger is automatically alleviated by electronic control unit (ECU) 29 and its associated wheel movement sensor 5 (Fig.1).

Referring to Figure 5, ECU 29 comprises an amplifier 29a which amplifies the electric signal from sensor 5 and feeds it to a delay timer 29b and a mono-stable 29c which briefly switches on a relay winding RW, briefly closing relay contacts RC and operating solenoid 24 (Figs 3 and 4) to re-set the pneumatic control system to the in-transport condition as soon as the speed exceeds a certain threshold (normally set below 10kph).

The circuitry is powered by its own rechargeable battery 39 which is charged (via voltage regulating means, not shown) from an auxiliary supply 40 such as the main vehicle battery. Accordingly the arrangement is not depended on the state of change of the main vehicle battery. Furthermore, the circuitry is arranged to minimise its power consumption by generating a delay period during which further re-setting of the pneumatic valve arrangement to the in-transport condition is prevented, as will become apparent from the following description of Figure 6.

Referring to Figure 6, amplifier 29a comprises transistors T1 and T2 and their associated resistors R1 to R7. The A.C. electric signal from sensor 5 (Fig. 1) appears as an input signal at S1 and is coupled to the amplifier by a capacitor C1.

Both the amplitude (O to 10V) and the frequency of this signal increase as the speed of rotation of the axles increases. The output of the amplifier, at the junction of R5 and the collector of T2, is clipped to a square wave even when the amplitude of the input signal is low and is applied to a trigger input 2 of ICl, an LC-555 timer. Consequently an output pulse is generated at output pin 3, which is transmitted to switching transistor T4 of monostable circuit 29c via a coupling capacitor C3 and a resistor R9. Diodes D1 and D2 are provided to protect transistor T4. The output pulse briefly operates a relay having winding RW and normally open contacts RC, and hence activates solenoid 24 (see also Figs. 3 and 4) for a few milliseconds, sufficient to re-set the pneumatic control arrangement to the "in transport" condition.

ICl is provided with a capacitor charging circuit comprising resistor R8, preset resistor P1 and capacitor C2 which is charged with DC from pin 3. When the charge on capacitor C2 reaches a certain threshold, the voltage at pins 6 and 7 rises to a value sufficient to re-set ICl. Only after it has been re-set can it be re-triggered by an amplified signal from rotation sensor 5. However, such charging of capacitor C2 and re-setting of ICl are prevented when the trailer axles are rotating by switching transistor T3 which is switched by the amplified square wave from aplifier 29a at each cycle thereof and repeatedly discharges capacitor C2.

Even after the signal at S1 ceases or diminishes below a threshold such that the output from aplifier 29a can no longer switch transistor T3, capacitor C2 takes about 2 minutes (variable up to 5 minutes by setting P1) to charge and re-set ICl. During this delay period ICl is insensitive to any re-appearance of a rotation signal at S1 and accordingly the possibility of needless repetition of the activation of solenoid 24, with consequential drain on the battery, is avoided.

The invention is not limited to trailers, and is applicable to other wheeled vehicles (not only road vehicles) having air suspensions.

The invention is capable of variation. For example, the height limiting valve may be eliminated and replaced by an internally regulated air supply. This will reduce the number of components required. There will be a direct pressurised air supply from the reservoir via a pipeline incorporating a non-return valve, the pressure regulator working from say 0 to 10 bar and a pressure gauge.

CLAIMS

1. A wheeled vehicle (100) having an air suspension arrangement comprising a load-carrying platform (7) supported on air springs (12-17), said vehicle having control means (200,300) for moving pressurised air to and from the air springs, said control means being responsive to an electric signal to activate said air suspension arrangement to an in-transport condition, the vehicle having wheel movement sensing means (5) arranged to detect movement of the wheels (11) of the vehicle and to generate said electric signal in response thereto.

2. A wheeled vehicle (100) according to Claim 1, wherein said control means (200,300) is responsive to said electric signal to raise said platform from a loading or unloading position to an in-transport position by pumping air into said air springs (12, 17).

3. A wheeled vehicle (100) according to Claim 1 or Claim 2 wherein said sensing means (5) comprises a rotation sensor coupled to an axle (9) carrying road wheels (11) of the vehicle.

4. A wheeled vehicle (100) according to any preceding Claim, having an antilock braking system (ABS) wherein said sensing means (S), comprises a rotation sensor of said antilock braking system.

5. A wheeled vehicle (100) according to any preceding Claim wherein said wheel movement sensing means (S) has an output coupled to a triggerable circuit means (29a, 29b, 29c) including a delay circuit (29b), said circuit

means being arranged to generate a switching signal in response to being triggered by said electric signal from said wheel movement sensing means, and on removal or diminution of said electric signal in response to cessation of wheel movement or a drop in speed below a predetermined threshold to reset itself to a triggerable condition after a delay period determined by said delay circuit (29b) said circuit means being unresponsive to any such electric signal from said wheel movement sensing means during said delay period and said control means (200,300) being responsive to said switching signal to activate said air suspension arrangement to said in-transport condition.

6. A wheeled vehicle (100) according to Claim 5, wherein said circuit means (29a, 29b, 29c) is energised by a battery (39).

7. A wheeled vehicle (100) according to Claim 5 or Claim 6 wherein said delay circuit (29b) includes a capacitor charging circuit (P1, R8, C2) including a capacitor (C2) which is coupled to a switchable discharging means (T3), said switchable discharging means being responsive to said electric signal to discharge said capacitor and thereby to prevent the initiation of said delay period until said electric signal ceases or diminishes below a threshold value.

8. A wheeled vehicle (100) according to any of Claims 5 to 7, wherein said wheel movement sensing means (5) comprises a permanent magnet variable reluctance drive unit.

9. A wheeled vehicle (100) according to any preceding claim wherein said control means comprises an electrically actuated pneumatic valve (23/36) which is energised in response to generation of said electric signal to adjust the height of said platform (7).

10. A wheeled vehicle (100) according to Claim 9 wherein said electrically operated pneumatic valve (23,26) is provided with mutually opposed biasing means and electric actuation means (24) and has an output port coupled to a pilot line of at least one memory valve (27, 28; 37, 38) said at least one memory valve having a state (ST2) in which one or more of said air springs (12-17) are coupled to an automatically controlled source of pressurised air (1,3, 4).

11) A wheeled vehicle (100) according to Claim 10, wherein said source of pressurised air (1,3,4) is controlled by a height control valve (4) which automatically adjusts the height of the platform (7).

12) A wheeled vehicle (100) according to Claim 10 or Claim 11, wherein said at least one memory valve (27, 28, 37, 38) has a further state (ST1) in which it couples manual controls (20, 21,22; 22^1, 33) to said air springs (12-17).

13) A wheeled vehicle (100) according to any preceding Claim, wherein said control means (200,300) includes manually operable dump means (21/33) which discharges air from said air springs (12-17) to lower said platform (7), said manually operable dump means being temporarily disabled in response to the generation of said electric signal.

14) A wheeled vehicle (100) according to any preceding Claim which is a trailer.

15) Each and every novel and inventive combination of components or sub-components as disclosed herein.

Patents Act 1977 Examiner's report to the Comptroller under Section 17 (The Search report) - 13 -	Application number GB 9416309.4
Relevant Technical Fields (i) UK Cl (Ed.M) B7D (DAJ) (ii) Int Cl (Ed.5) B60G 17/056	Search Examiner COLIN THOMPSON Date of completion of Search 31 OCTOBER 1994
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii) ONLINE DATABASE: EPODOC	Documents considered relevant following a search in respect of Claims :- 1 TO 14

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A:	Document indicating technological background and/or state of the art.	**&:**	Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
X	WO 92/12021 A1	(IMS LTD) see especially page 4 lines 11 to 17	1, 2, 3, 4, 9, 14
X	EP 0520147 A1	(GRAU GMBH)	1, 2, 3, 4, 9

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